

AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior versions, and listings of claims in the application:

LISTING OF CLAIMS:

Claims 1-26 (cancelled)

27. (new) A functionalized carbon nanotube, the surface of which carries covalently bound reactive and/or activable functional groups which are homogeneously distributed on said surface, said functionalized carbon nanotube being substantially intact and soluble in organic and/or aqueous solvents.

28. (new) A functionalized carbon nanotube according to claim 27, wherein said carbon nanotube is a single-walled (SWNT) or a multi-walled carbon nanotube (MWNT).

29. (new) A functionalized carbon nanotube according to claim 28, wherein the organic solvents are selected from a group comprising dimethylformamide, dichloromethane, chloroform, acetonitrile, dimethylsulfoxide, methanol, ethanol, toluene, isopropanol, 1,2-dichloroethane, N-methylpyrrolidone, tetrahydrofuran.

30. (new) A functionalized carbon nanotube according to claim 29, of following general formula:  $[C_n]-X_m$

wherein:

$C_n$  are surface carbons of a substantially cylindrical carbon nanotube of substantially constant diameter, said diameter being from about 0.5 to about 50 nm, in

particular from about 0.5 to 5 nm for SWNTs and from about 20 to about 50 nm for MWNTs,

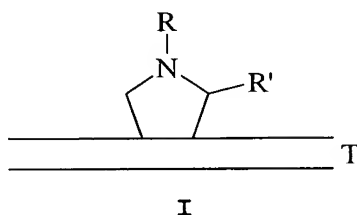
X is a functional group,

n is an integer from about  $3 \cdot 10^3$  to about  $3 \cdot 10^6$ ,

m is an integer from about  $0.001n$  to about  $0.1n$ ,

there are from about  $2 \cdot 10^{-11}$  moles to about  $2 \cdot 10^{-9}$  moles of X functional groups per  $\text{cm}^2$  of carbon nanotube surface.

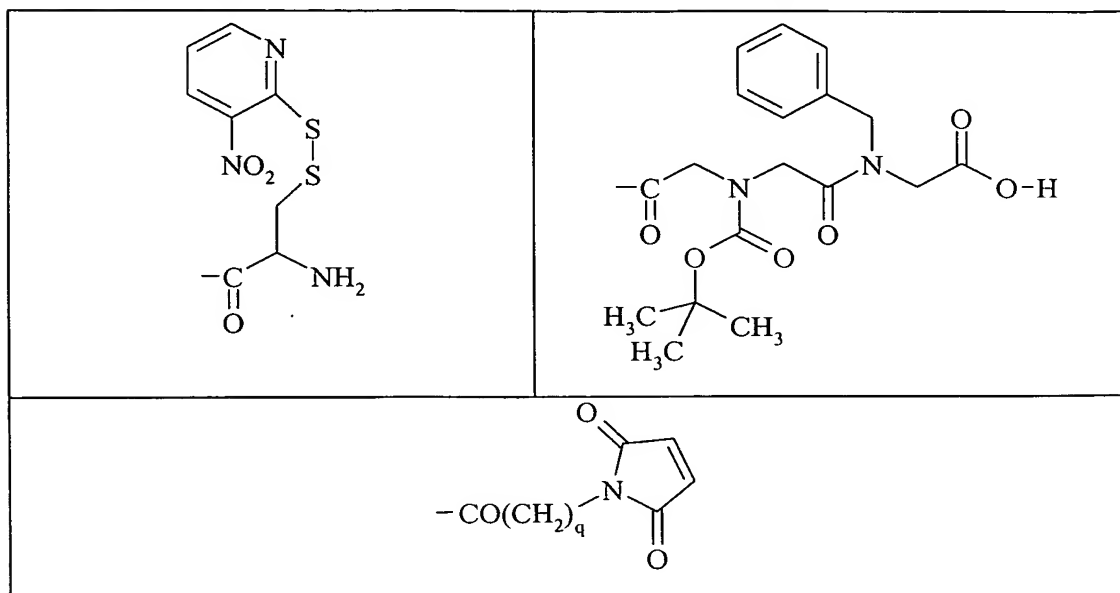
31. (new) A functionalized carbon nanotube according to claim 30, wherein X is a pyrrolidine ring, of the following general formula (I):



wherein T represents a carbon nanotube, and independently from each other R and R' represent -H or a group of formula -M-Y-(Z)<sub>a</sub>-(P)<sub>b</sub>, wherein independently from each other a and b represent 0 or 1, provided R and R' cannot simultaneously represent H, and:

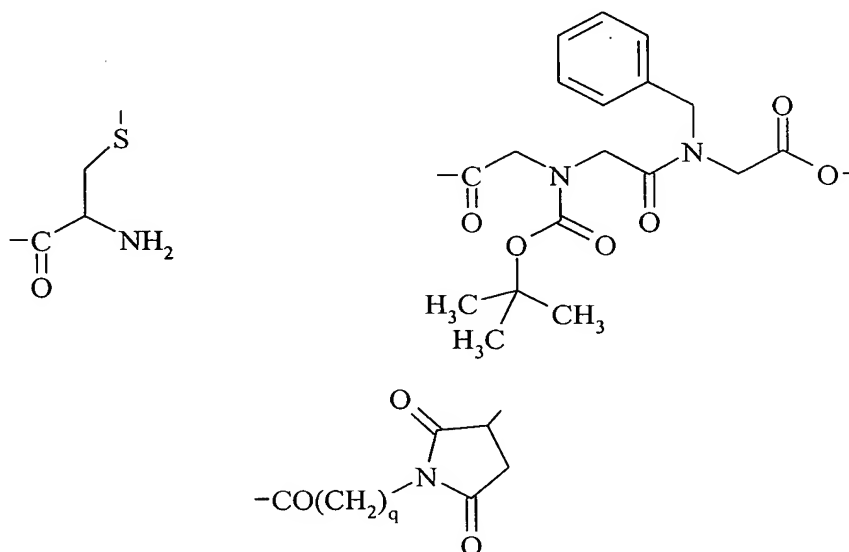
- M is a spacer group from about 1 to about 100 atoms, such as a group selected from the list comprising  $-(\text{CH}_2)_r-$  or  $-(\text{CH}_2-\text{CH}_2-\text{O})_r-\text{CH}_2-\text{CH}_2-$ , wherein r is an integer from 1 to 20;
- Y is a reactive group when  $a=b=0$ , such as a group selected from the list comprising -OH, -NH<sub>2</sub>, -COOH, -SH, -CHO, a ketone such as -COCH<sub>3</sub>, an azide or a halide; or derived from a reactive group, when a or b is different from 0, such as a group selected from the list comprising -O-, -NH-, -COO-, -S-, -CH=, -CH<sub>2</sub>-,  $-\text{CC}_k\text{H}_{2k+1}=$ , wherein k is an integer from 1 to 10, in particular -CCH<sub>3</sub>=, or  $-\text{CHC}_k\text{H}_{2k+1}-$ , wherein k is an integer from 1 to 10, in particular -CHCH<sub>3</sub>-;

- Z is a linker group, liable to be linked to a P group, and if need be to release said P group, such as a group of one of the following formulae when a=1 and b=0:



wherein q is an integer from 1 to 10;

or of one of the corresponding following formulae when a=1 and b=1:

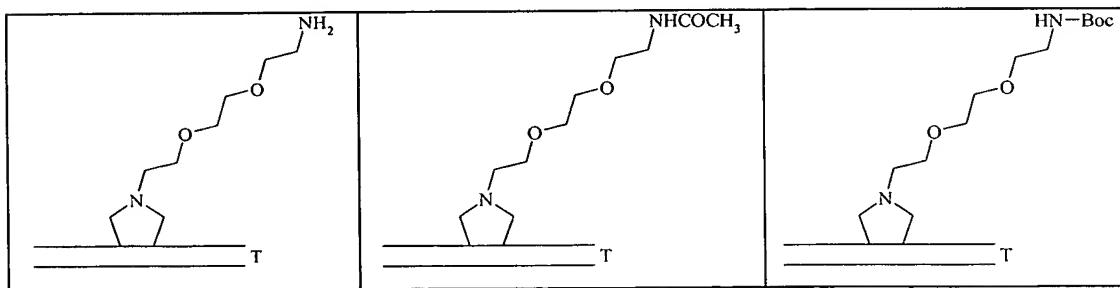


wherein q is an integer from 1 to 10;

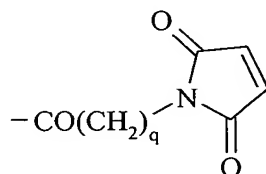
- P is an effective group allowing spectroscopic detection of said functionalized carbon nanotube, such as a fluorophore, such as FITC, or an active molecule, liable to induce a biological effect, such as an amino acid, a peptide, a pseudopeptide, a protein, such as an enzyme or an antibody, a nucleic acid, a carbohydrate, or a drug.

if appropriate at least one of Y, Z, or P groups, can be substituted by a capping group, such as  $\text{CH}_3\text{CO}-$  (acetyl), methyl, or ethyl, or a protecting group such as methyl, ethyl, benzyl, *tert*-butyl, trityl, 3-nitro-2-pyridylsulfenyl, *tert*-butoxycarbonyl (Boc), fluorenylmethoxycarbonyl (Fmoc), benzylcarbonyl, trimethylsilylethoxycarbonyl, phthalimide, dimethylacetal, diethylacetal or, 1,3-dioxolane.

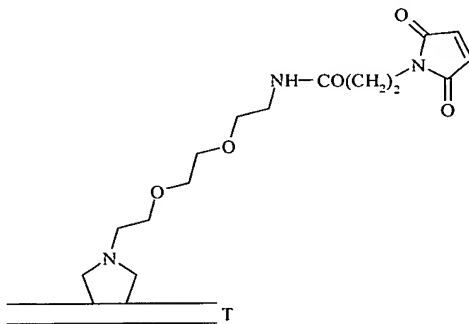
32. (new) A functionalized carbon nanotube according to claim 31, wherein  $a=b=0$  and Y is a reactive group selected from the list comprising  $-\text{OH}$ ,  $-\text{NH}_2$ ,  $-\text{COOH}$ ,  $-\text{SH}$ ,  $-\text{CHO}$ , a ketone, such as  $-\text{COCH}_3$ , an azide, or a halide, in particular  $-\text{NH}_2$ , said functionalized carbon nanotube being, if appropriate, substituted by a capping or a protecting group, in particular a Boc or acetyl group, and being for instance a functionalized carbon nanotube of one of the following formulae:



33. (new) A functionalized carbon nanotube according to claim 31, wherein  $a=1$  and  $b=0$ , Y is derived from a reactive group and selected from the list comprising  $-O-$ ,  $-NH-$ ,  $-COO-$ ,  $-S-$ ,  $-CH=$ ,  $-CH_2-$ ,  $-CC_kH_{2k+1}=$ , wherein  $k$  is an integer from 1 to 10, in particular  $-CCH_3=$ , or  $-CHC_kH_{2k+1}-$ , wherein  $k$  is an integer from 1 to 10, in particular  $-CHCH_3-$ , and Z represents in particular the group of the following formula:

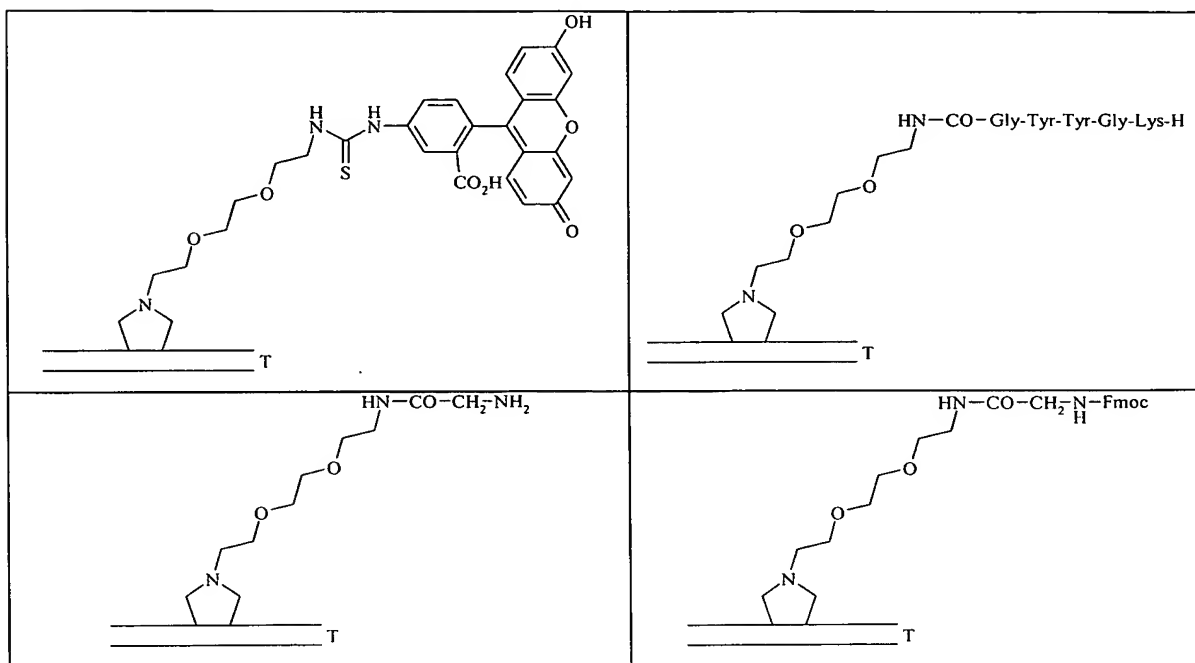


wherein  $q$  is an integer from 1 to 10, said functionalized carbon nanotube being if appropriate substituted by a protecting group being for instance the functionalized carbon nanotube of the following formula:

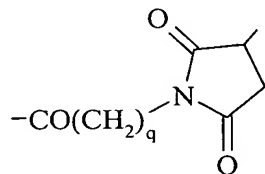


34. (new) A functionalized carbon nanotube according to claim 31, wherein  $a=0$  and  $b=1$ , Y is derived from a reactive group and selected from the list comprising  $-O-$ ,  $-NH-$ ,  $-COO-$ ,  $-S-$ ,  $-CH=$ ,  $-CH_2-$ ,  $-CC_kH_{2k+1}=$ , wherein  $k$  is an integer from 1 to 10, in particular  $-CCH_3=$ , or  $-CHC_kH_{2k+1}-$ , wherein  $k$  is an integer from 1 to 10, in particular  $-CHCH_3-$ , and P is an effective group or an active molecule, in particular FITC, an amino acid, such as glycine, or a peptide, such as the peptide H-Lys-Gly-Tyr-Tyr-Gly-OH, said functionalized carbon nanotube being if appropriate substituted by a protecting group, such

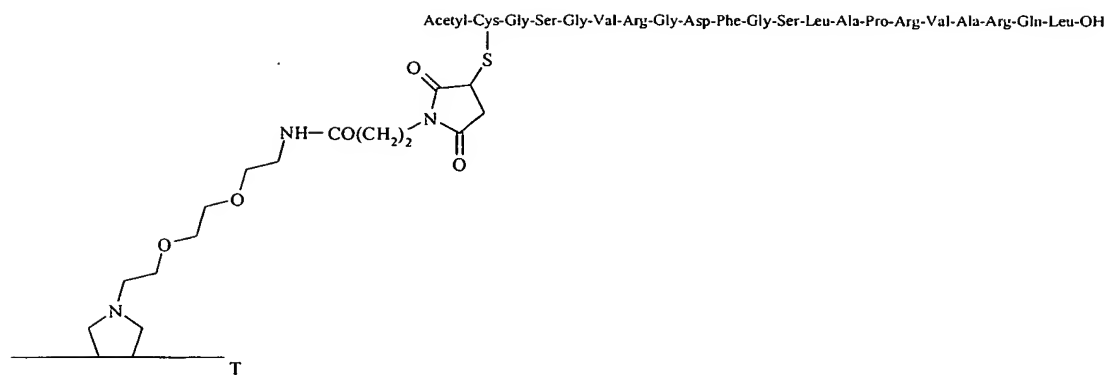
as Fmoc, and being for instance a functionalized carbon nanotube of one of the following formulae:



35. (new) A functionalized carbon nanotube according to claim 31, wherein  $a=1$  and  $b=1$ , Y is derived from a reactive group and selected from the list comprising  $-O-$ ,  $-NH-$ ,  $-COO-$ ,  $-S-$ ,  $-CH=$ ,  $-CH_2-$ ,  $-CC_kH_{2k+1}=$ , wherein k is an integer from 1 to 10, in particular  $-CCH_3=$ , or  $-CHC_kH_{2k+1}-$ , wherein k is an integer from 1 to 10, in particular  $-CHCH_3-$ , Z represents in particular the group of the following formula:

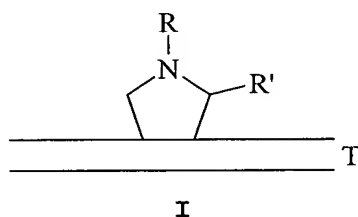


wherein q is an integer from 1 to 10, and P is a peptide, such as the peptide Acetyl-Cys-Gly-Ser-Gly-Val-Arg-Gly-Asp-Phe-Gly-Ser-Leu-Ala-Pro-Arg-Val-Ala-Arg-Gln-Leu-OH, said functionalized carbon nanotube being if appropriate substituted by a protecting group, being for instance the functionalized carbon nanotube of the following formula:



36. (new) A functionalized carbon nanotube according to claim 34, wherein P is a peptide or a protein, said peptide or protein comprising in particular a B cell epitope or a T cell epitope, such as a T helper epitope or a T cytotoxic epitope, or a mixture thereof.

37. (new) A process for preparing a functionalized carbon nanotube of the following formula I:



wherein T represents a carbon nanotube and independently from each other R and R' represent -H or a group of formula -M-Y, provided R and R' cannot simultaneously represent H, wherein:

- -M- is a spacer group from about 1 to about 100 atoms, such as a group selected from the list comprising - $(\text{CH}_2)_r$ - or  $-(\text{CH}_2-\text{CH}_2-\text{O})_r-\text{CH}_2-\text{CH}_2-$ , wherein r is an integer from 1 to 20;
- -Y is a reactive group, such as a group selected from the list comprising, -OH, -NH<sub>2</sub>, -COOH, -SH, -CHO, a ketone such as -COCH<sub>3</sub>, an azide, a halide, if

appropriate protected, such as -O-Q, -NH-Q, -COO-Q, -

S-Q,  $-\text{CH}(\text{OQ})_2$ ,  $\begin{array}{c} \text{---C---C}_k\text{H}_{2k+1} \\ \diagup \quad \diagdown \\ \text{O} \quad \text{Q} \end{array}$  wherein k is an integer from

1 to 10, in particular  $\begin{array}{c} \text{---C---CH}_3 \\ \diagup \quad \diagdown \\ \text{O} \quad \text{Q} \end{array}$ , wherein Q is a protecting group or forms a protecting group with the adjacent atoms to which it is linked;

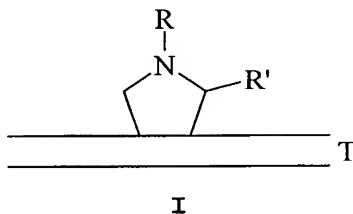
said process comprising the following step:

- adding, to a carbon nanotube, the compounds R'-CHO and R-NH-CHR''-COOR''' by a 1,3-dipolar cycloaddition, wherein:
  - R and R' are as defined above;
  - R'' is -H or an amino acid side-chain;
  - R''' is -H, an alkyl group of 1 to 5 carbon atoms, a  $(\text{CH}_2\text{CH}_2\text{O})_t\text{-CH}_3$  group, wherein t is an integer from 1 to 20, or an aromatic group;

to obtain a functionalized carbon nanotube of formula I, if appropriate protected;

- if necessary, deprotecting the functionalized carbon nanotube of formula I, to obtain an unprotected functionalized carbon nanotube of formula I.

38. (new) A process for preparing a functionalized carbon nanotube of the following formula I:

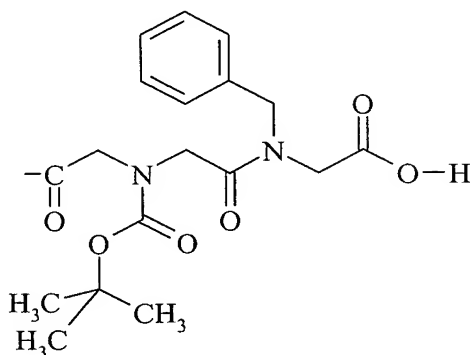
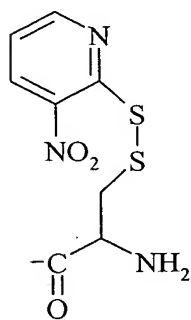
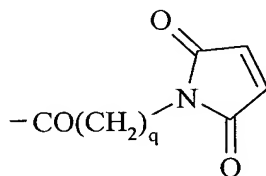


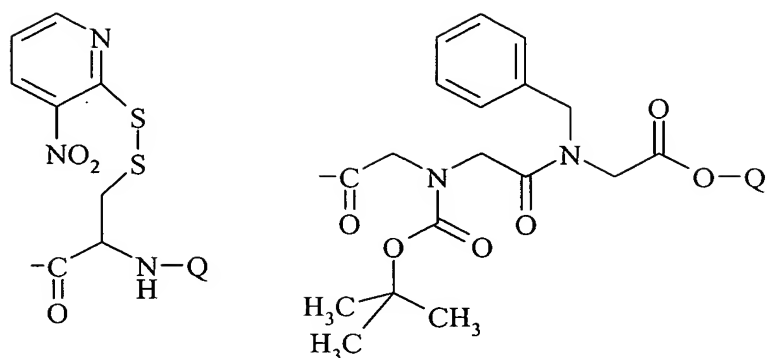
wherein T represents a carbon nanotube and independently from each other R and R' represent -H or a group of formula



-M-Y-Z, provided R and R' cannot simultaneously represent -H, wherein:

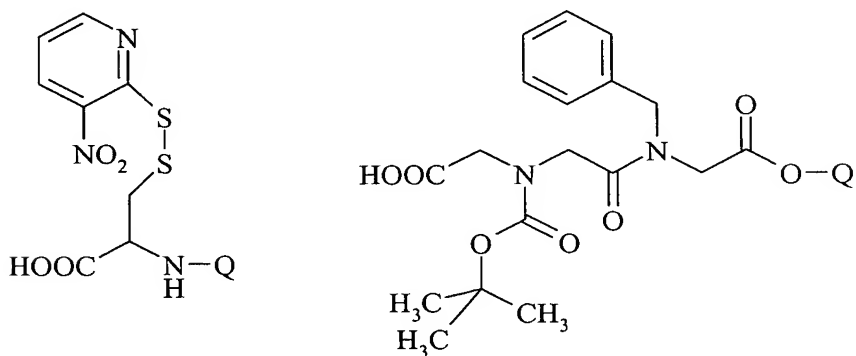
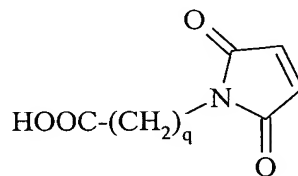
- -M- is a spacer group from about 1 to about 100 atoms, such as a group selected from the list comprising  $-(CH_2)_r-$  or  $-(CH_2-CH_2-O)_r-CH_2-CH_2-$ , wherein r is an integer from 1 to 20;
- -Y- is a group derived from a reactive group, such as a group selected from the list comprising, -O-, -NH-, -COO-, -S-, -CH=, -CH<sub>2</sub>-, -CC<sub>k</sub>H<sub>2k+1</sub>=, wherein k is an integer from 1 to 10, in particular -CCH<sub>3</sub>=, or -CHC<sub>k</sub>H<sub>2k+1</sub>-, wherein k is an integer from 1 to 10, in particular -CHCH<sub>3</sub>-;
- -Z is a linker group, liable to be linked to a P group, and if need be to release said P group, if appropriate protected by a capping or a protecting group -Q, such as a group of one of the following formulae:





wherein  $q$  is an integer from 1 to 10;  
said process comprising the following steps:

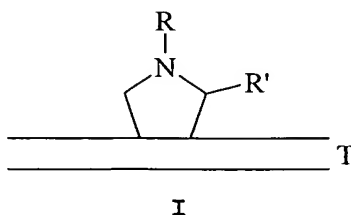
- adding to a unprotected functionalized carbon nanotube of formula I according to claim 37 a linker group of formula Z, if appropriate protected by a capping or a protecting group -Q, such as a group of one of the following formulae:



wherein  $q$  is an integer from 1 to 10;  
to obtain a functionalized carbon nanotube of formula I, if appropriate protected;

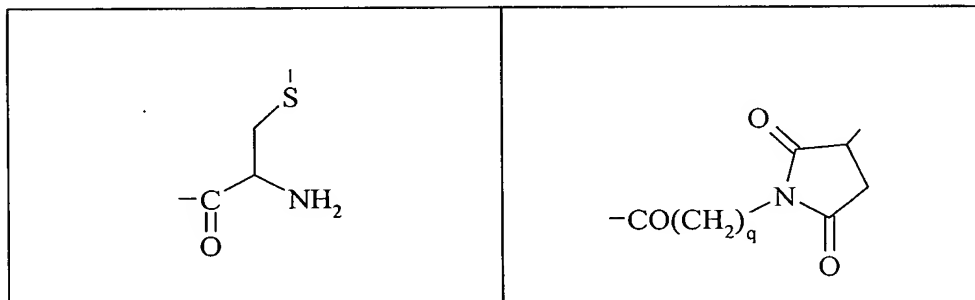
- if necessary, deprotecting the functionalized carbon nanotube of formula I, to obtain an unprotected functionalized carbon nanotube of formula I.

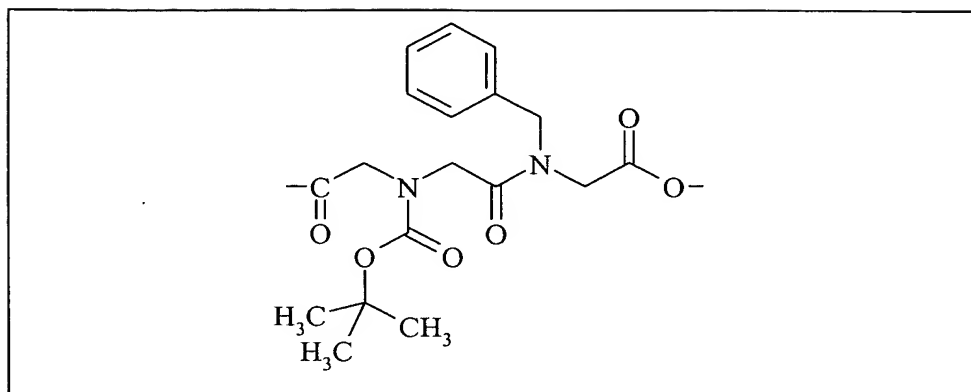
39. (new) A process for preparing a functionalized nanotube of the following formula I:



wherein T represents a carbon nanotube and independently from each other R and R' represent -H or a group of formula -M-Y-Z-P or of formula -M-Y-P, provided R and R' cannot simultaneously represent -H, wherein:

- -M- is a spacer group from about 1 to about 100 atoms, such as a group selected from the list comprising - $(\text{CH}_2)_r$ - or  $-(\text{CH}_2\text{-CH}_2\text{-O})_r\text{-CH}_2\text{-CH}_2\text{-}$ , wherein r is an integer from 1 to 20;
- -Y- is a group derived from a reactive group, such as a group selected from the list comprising, -O-, -NH-, -COO-, -S-, -CH=, -CH<sub>2</sub>-, -CC<sub>k</sub>H<sub>2k+1</sub>=, wherein k is an integer from 1 to 10, in particular -CCH<sub>3</sub>=, or -CHC<sub>k</sub>H<sub>2k+1</sub>-, wherein k is an integer from 1 to 10, in particular -CHCH<sub>3</sub>-;
- -Z- is a linker group, liable to be linked to a P group, and if need be to release said P group, such as a group of one of the following formulae:

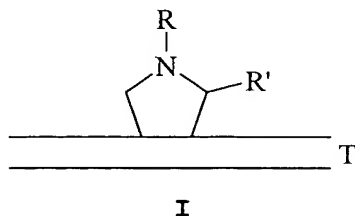




wherein q is an integer from 1 to 10;

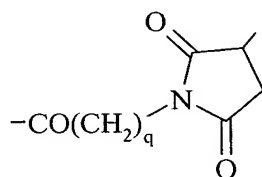
- -P is an effective group allowing spectroscopic detection of said functionalized carbon nanotube, such as a fluorophore, such as FITC, or an active molecule, liable to induce a biological effect, if appropriate protected, such as an amino acid, a peptide, a pseudopeptide, a protein, such as an enzyme or an antibody, a nucleic acid, a carbohydrate, or a drug;
- said process comprising the following steps:
- adding to an unprotected functionalized carbon nanotube of formula I according to claim 37, an effective group or an active molecule of formula P, if appropriate protected, such as a fluorophore, such as FITC, an amino acid, a peptide, a pseudopeptide, a protein, such as an enzyme or an antibody, a nucleic acid, a carbohydrate, or a drug,
  - or adding to an unprotected functionalized carbon nanotube of formula I, a group of formula Z-P, if appropriate protected,
  - to obtain a functionalized carbon nanotube of formula I, if appropriate protected;
  - if necessary, deprotecting the functionalized carbon nanotube of formula I, to obtain an unprotected functionalized carbon nanotube of formula I.

40. (new) A process for preparing a peptide or protein functionalized carbon nanotube, of the following formula I:



wherein T represents a carbon nanotube and independently from each other R and R' represent H or a group of formula -M-Y-P, or of formula -M-Y-Z, provided R and R' cannot simultaneously represent -H, wherein:

- -M- is a spacer group from about 1 to about 100 atoms, such as a group selected from the list comprising  $-(CH_2)_r-$  or  $-(CH_2-CH_2-O)_r-CH_2-CH_2-$ , wherein r is an integer from 1 to 20;
- -Y- is a group derived from a reactive group, such as a group selected from the list comprising, -O-, -NH-, -COO-, -S-, -CH=, -CH<sub>2</sub>-, -CC<sub>k</sub>H<sub>2k+1</sub>=, wherein n is an integer from 1 to 10, in particular -CCH<sub>3</sub>=, or -CHC<sub>k</sub>H<sub>2k+1</sub>-, wherein k is an integer from 1 to 10, in particular -CHCH<sub>3</sub>-;
- -Z- is a linker group, in particular a group of the following formula:

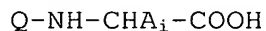


wherein q is an integer from 1 to 10;

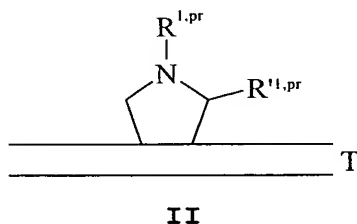
- -P is a peptide, in particular of following formula:  $-[OC-CH(A_i)-NH]_t-H$ , wherein -A<sub>i</sub> is an amino acid side-chain, i is an integer from 1 to t and t is an integer from 1 to 150, advantageously from 1 to 50;

said process comprising the following steps:

- adding to a functionalized carbon nanotube of formula I, according to claim 37, a protected amino acid of the following formula:

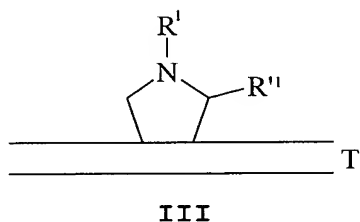


wherein  $-A_i$  is as defined above and  $-Q$  is a protecting group to obtain a functionalized carbon nanotube of the following formula II:



wherein independently from each other  $R^{1,pr}$  and  $R'^{1,pr}$  represent  $-H$  or a group of formula  $-M-Y-OC-CH_{A_i}-NH-Q$ , or of formula  $-M-Y-Z-OC-CH_{A_i}-NH-Q$ , wherein  $-M-$ ,  $-Y-$ ,  $-Z-$ ,  $-A_i$  and  $-Q$  are as defined above;

- deprotecting the functionalized carbon nanotube of formula II to obtain a functionalized carbon nanotube of the following formula III:

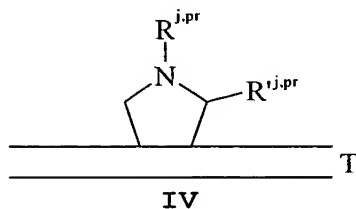


wherein independently from each other  $R^1$  and  $R'^1$  represent  $-H$  or a group of formula  $-M-Y-OC-CH_{A_i}-NH_2$ , or of formula  $-M-Y-Z-OC-CH_{A_i}-NH_2$ , wherein  $-M-$ ,  $-Y-$ ,  $-Z-$ , and  $-A_i$  are as defined above;

- adding to the functionalized carbon nanotube obtained at the preceding step a protected amino acid of the following formula:

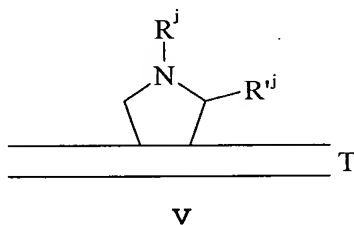


wherein  $-A_i$  is as defined above and  $-Q$  is a protecting group to obtain a functionalized carbon nanotube of the following formula IV:



wherein independently from each other  $R^{j,pr}$  and  $R^{i,j,pr}$  represent  $-H$  or a group of formula  $-M-Y-[OC-CHA_i-NH]_j-Q$ , or of formula  $-M-Y-Z-[OC-CHA_i-NH]_j-Q$ , wherein  $-M-$ ,  $-Y-$ ,  $-Z-$ ,  $-A_i$  and  $-Q$  are as defined above, and  $j$  is an integer from 2 to  $t$ ;

- deprotecting the functionalized carbon nanotube of formula IV to obtain a functionalized carbon nanotube of the following formula V:



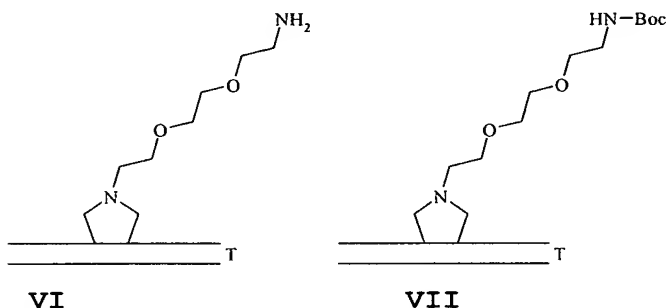
wherein independently from each other  $R^j$  and  $R^{ij}$  represent  $-H$  or a group of formula  $-M-Y-[OC-CHA_i-NH]_j-H$ , or of formula  $M-Y-Z-[OC-CHA_i-NH]_j-H$ , wherein  $-M-$ ,  $-Y-$ ,  $-Z-$ , and  $-A_i$  are as defined above, and  $j$  is an integer from 2 to  $t$ ;

- repeating the last two steps  $t-1$  times to obtain a peptide or protein functionalized carbon nanotube of formula I.

41. (new) A process according to claim 38, wherein  $-Q$  is a capping group, such as  $CH_3CO-$  (acetyl), methyl, or ethyl, or a protecting group, such as a group selected from the list comprising methyl, ethyl, benzyl, *tert*-butyl, trityl, 3-nitro-

2-pyridylsulfenyl, *tert*-butyloxycarbonyl (Boc),  
 fluorenylmethyloxycarbonyl (Fmoc), benzylcarbonyl,  
 trimethylsilylethyloxycarbonyl, phthalimide, or ethyleneoxy.

42. (new) A process for preparing a functionalized carbon nanotube of one of the following formulae VI and VII:

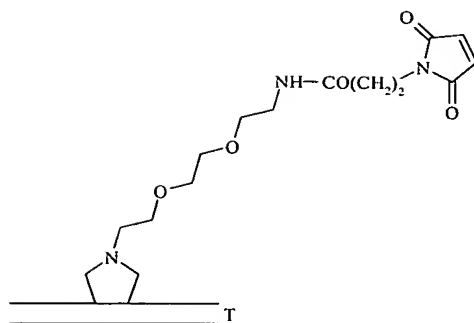


wherein T represents a carbon nanotube and Boc represents *tert*-butyloxycarbonyl, said process comprising the following steps:

- adding, to a carbon nanotube, the compounds  $(\text{CH}_2\text{O})_n$  (*para*formaldehyde) and  $\text{Boc-NH}-(\text{CH}_2-\text{CH}_2-\text{O})_2-\text{CH}_2-\text{CH}_2-\text{NH}-\text{CH}_2-\text{COOH}$  by a 1,3-dipolar cycloaddition, to obtain a protected functionalized carbon nanotube of formula VII;
- if necessary, deprotecting the protected functionalized carbon nanotube of formula VII, to obtain an unprotected functionalized carbon nanotube of formula VI.

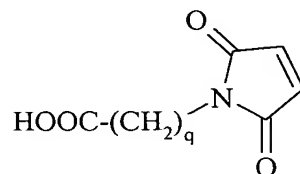
43. (new) A process for preparing a functionalized carbon nanotube of the following formula VIII:



**VIII**

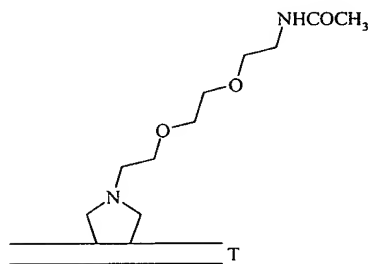
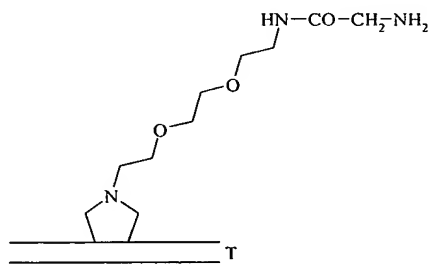
wherein T represents a carbon nanotube, said process comprising the following step:

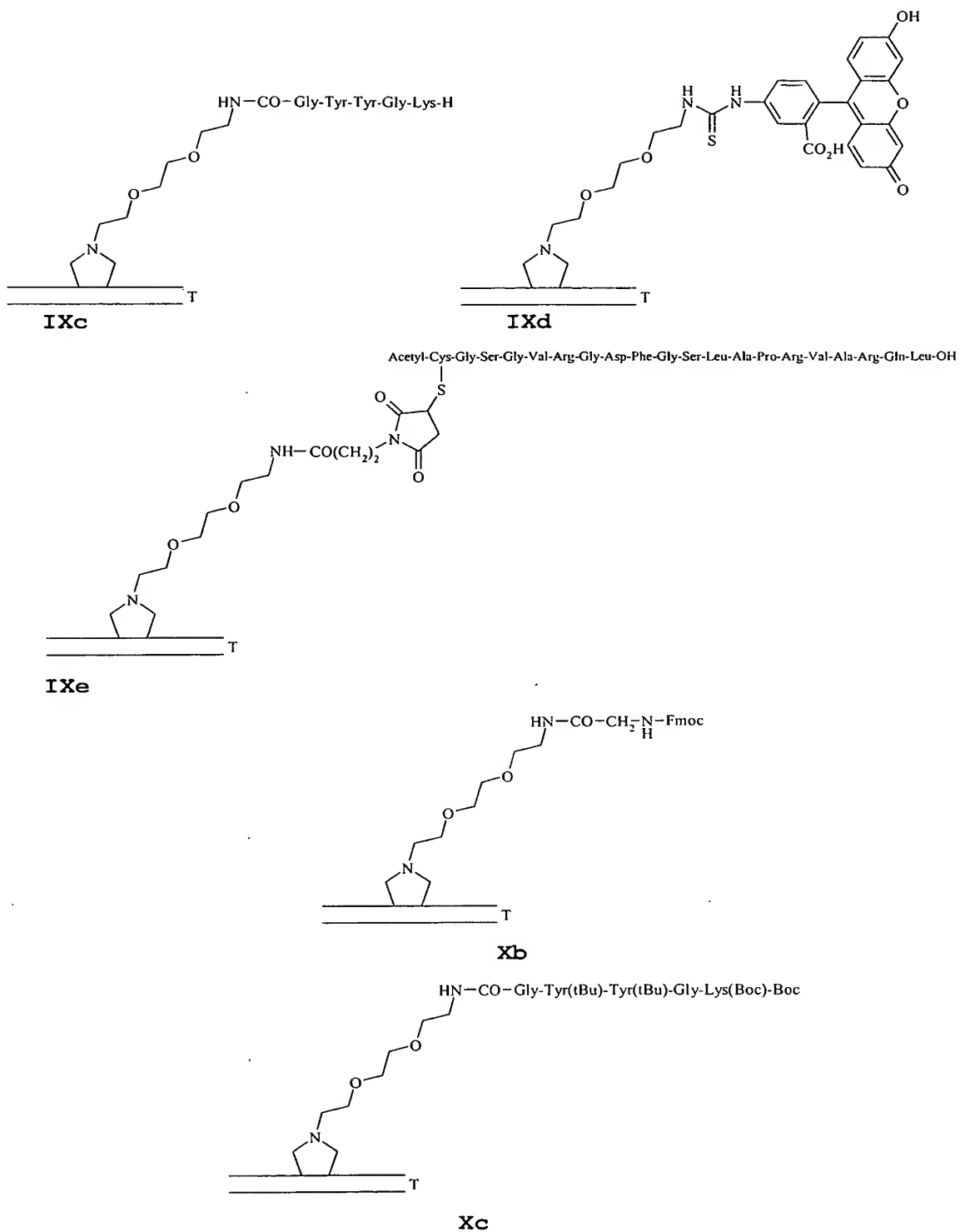
- adding, to a carbon nanotube of formula VI according to claim 42, a compound of the following formula:



to obtain a functionalized carbon nanotube of formula VIII.

44. (new) A process for preparing a functionalized carbon nanotube of one of the following formulae IXa, IXb, IXc, IXd, IXe, Xb and Xc:

**IXa****IXb**



wherein T represents a carbon nanotube, Fmoc represents fluorenylmethyloxycarbonyl, tBu represents tert-butyl and

Boc represents tert-butyloxycarbonyl, said process comprising the following steps:

- adding,
  - either to a functionalized carbon nanotube of formula VI according to claim 42, a group chosen among:  $\text{CH}_3\text{-COOH}$ , Fmoc-Gly-OH, Boc-Lys(Boc)-Gly-Tyr(tBu)-Tyr(tBu)-Gly-OH, or FITC,
  - or to a functionalized carbon nanotube of formula VIII, the following group, Acetyl-Cys-Gly-Ser-Gly-Val-Arg-Gly-Asp-Phe-Gly-Ser-Leu-Ala-Pro-Arg-Val-Ala-Arg-Gln-Leu-OH,
 to obtain a functionalized carbon nanotube of respective formula IXa, Xb, Xc, IXd or IXe;
- if necessary, deprotecting the functionalized carbon nanotube of formula Xb or Xc to obtain respectively the functionalized carbon nanotube of formula IXb or IXc.

45. (new) A functionalized carbon nanotube such as obtained by the process of claim 37.

46. (new) A pharmaceutical composition comprising as active substance at least one functionalized carbon nanotube according to claim 27, in association with a pharmaceutically acceptable vehicle, such as a liposome, a cyclodextrin, a microparticle, a nanoparticle, or a cell penetrating peptide.

47. (new) A method of transport of pharmaceutically active molecules comprising the use of a functionalized carbon nanotube according to claim 27.

48. (new) A method of delivery of drugs, in particular of intracellular delivery of drugs, comprising the use of an

appropriate amount of a functionalized carbon nanotube according to claim 27.

49. (new) A method of preparation of an immunogenic composition intended to provide an immunological protection to the individual to whom it has been administered, comprising the use of an appropriate amount of a functionalized carbon nanotube according to claim 27.

50. (new) A method for the treatment or the prophylaxis of cancer, autoimmune or infectious diseases, comprising the administration of an appropriate amount of a functionalized carbon nanotube according to claim 27.

51. (new) A method of preparation of functionalized surfaces such as plastic or glass surfaces comprising the use of a functionalized carbon nanotube according to claim 27.

52. (new) A method of preparation of electrochemical biosensors comprising the use of a functionalized carbon nanotube according to claim 27.